A

1.2 Ghz

Repeater Project

by:
J. Austin
WA6RLV

03-20-92

A 1.2 Ghz Home Brew Repeater

Recently, there has been a renewed interest in the 1.2 Ghz band, especially for FM enthusiasts. The need for repeaters has been met only by Icom, and the various 1.2 Ghz repeaters offered by them are expensive.

This article is an attempt to describe the ideas and construction methods used in building this project. The repeater project can be divided into four areas, the transverter, the high band transceiver and driver,the power amplifier, and final adjustments.

The Base Band, 2M Radio

The basic concept of this repeater is a high band (2 meter) radio coupled to a 1.2 Ghz transverter using two power modules to obtain 10 to 15 watts output. The building block for this project is the G.E. Master Executive II high band mobile transceiver. These particular radios have become readily available to many because they were recently removed from service with the California Highway Patrol. The radio has all the R.F. boards (both exciter and receiver) mounted on one side of the chassis. The large circuit boards on the other side of the chassis are not used and can be removed and discarded (after unsoldering and removing the plugs that connect the large circuit boards to the exciter and receiver). The removal of these large boards on the bottom of the chassis leaves more than adequate room for the two transverter boards to be installed later.

Insert the pins from the circuit boards, through the chassis into the exciter board and receiver board for wiring. Using a LM317 variable regulator, make a voltage regulator and set the regulated voltage to 10 volts. Be sure to heat sink the tab to the chassis, a 6-32 stud is located in one corner near the front panel for this purpose. (See figure 1). On the exciter board, pins 2, 5, 6 and 7 are ground, pin 8 is continuous +10 volts, pin 1 is +10 volts switched with the PTT relay, pin 4 is mic hi, pin 9 is PL hi, pin 3 is connected to pin 5 on the receiver board. Point to point wiring of these connections to the PTT relay, voltage regulator, repeater controller, and receiver board is next.

Some interface will be required between the exciter and the PL generator and the receiver audio. From the sub-audible tone generator, a 10K resistor is placed in series with the audio to pin 9 of the exciter board, with a .001 uf capacitor to ground from pin 9. From the receiver audio (pin 1 on the receiver board), a 6.8K resistor is put in series to pin 4 and a .001 uf capacitor to ground from the exciter side of the resistor.

The Receiver

The receiver is very straight forward. After installing the crystal, peak up the multiplier chain and insert a strong, on channel signal at the High Band antenna input and tune the mixer and front end. The audio signal is present on pin 1 of the receiver board connecter. Some alignment of the detector coil (T604) may be required for symmetrical audio. This is best done with an audio signal inserted into the RF generator and a scope looking across the audio output. Tune T604 for symmetrical waveform on the scope and maximum audio signal. Set the receiver on channel.

The receiver connector pins are: Pin 1; audio output, Pin 2; (no connection), Pins 3 & 10; +10 V, Pins 4 & 6; chassis ground, Pin 5; temp. compensator (Tx pin 3).

There is no squelch circuit in the receiver. If you plan on running your repeater with the receiver operating in "carrier squelch", you will want to build a squelch. There are several ICs on the market that would do the job nicely. This repeater was built to run with "tone squelch" only, so no squelch was added. Instead, a Communications Specialists TS-32 sub-audible tone encoder and decoder was used. To switch the PTT line, the switched output from the tone decoder works well.

The Exciter

The exciter is very basic. Using a multi-meter, measure pin 2 (of the test socket) and peak L101, L102 and dip T101. Now measure pin 1 and peak T101, T102 and dip T103. Measure pin 3 and peak T103, T104 and dip T105. Measure pin 9 and peak T105 and T106. Measure pin 6 and peak T107 and T108. Now inject and audio signal on the Mic Hi and tune L101 for audio clarity. Inject the sub-audible tone on CG Hi and tune L102 for tone clarity. Listen to the output of the exciter on a monitor and balance tune L101 and L102 for minimum tone intermodulation and distortion.
The exciter will put out too much power (200-300 Miliwatts), so a simple attenuator T pad is required (1/2 watt, 20 ohms in series with another 20 ohms and 30 ohms to ground on a small PC board).

Consider taking the low-pass filter from the heatsink assembly and mounting it next to the exciter board. Route the exciter output through the filter, then to the attenuator and on to the converter. This last step is not required, but it will reduce spurious signals from the final transmitted signal. The converter is broadband and will allow unwanted signals from the exciter to pass and be amplified.

The Transverter

The transverter used in this project is the SHF 124ØK, 124Ø-13ØØ Mhz Linear Transmit/Receive Converter and SHF-LO, local oscillator, available assembled or in kit form from Down East Microwave. The kit includes all the parts necessary, including the crystal and instructions. If the kit is purchased, the instructions should be carefully read several times, as they are rather vague. Construction techniques are important and care should be taken when soldering the surface-mount components. A magnifying glass is helpful when examining the MMICs to determine the location of the dot or slashed lead that indicates the device's input or output.

The transverter is broad-band and stable. If it is assembled properly, there is no tuning required, except to set the crystal on frequency. A low temperature crystal oven will help the stability of the high frequency oscillator, especially if the repeater is to be put in an environment with large temperature changes.

Mount the converter board flat onto the chassis. this will require removing the receiver assembly, drilling out the existing stand-offs and drilling at least six (6) holes through the chassis and the converter board (use caution here, don't drill through any of the traces and leave adequate room for washers and nuts). Counter-sink the holes from the receiver side of the chassis and use flathead 6-32 screws, mounting the flat washers and nuts on the converter board.

The Driver & Power Amplifier

The Driver and PA stages are RF power modules. The Driver module is a Mitsubishi M67715 that puts out 1 to 1.5 watts. The PA module is a Mitsubishi M57762 that puts out 1Ø to 15 watts. These parts and their specification sheets can be ordered from RF Parts Co.

The modules mount to the inside of the heatsink assembly. A good quality teflon coax should be used to the driver, from the transverter. From the Driver to the PA, and from the PA to the transmit antenna connector, small rigid hardline should be used. Keep in mind when building this, that 1/4 wavelength is 2 1/8 inches and any multiple or fraction of this distance can cause oscillations in the amplifiers. With the use of hardline and a copper ground plane, soldering the hardline to the groundplane will help eliminate this problem. As in all UHF projects, lead length is critical and should be kept as short as possible.

Each module requires bypass capacitors on the DC supply pins to prevent low frequency oscillations. If at all possible these should be surface-mount, chip capacitors of the appropriate values. The circuit boards required for the modules are very basic and only require pads to solder the module pins to, with a good ground plane around them. Also important is the quality of the circuit board. A double sided fiberglass board is recommended.

A separate LM 317 (variable voltage regulator) should be used for each power module and the voltages set as recommended by the specification sheets supplied with the modules. This also will allow the builder to adjust the power levels of each stage. A small resistor, about 5 ohms, should be placed in series with the center conductor of the hardline between the output of the driver and the input of the PA. This serves to isolate the two stages and prevent feedback.

The output of the PA stage should be routed through small hardline to a N type connector, being sure to maintain a coaxial type coupling to the connector. At these frequencies, it is very important to maintain impedances. Seemingly small inconsistencies or impedance "bumps" can cost several Db's.

Final Adjustments

A service monitor is the ideal instrument for adjusting audio levels and deviation. Service monitors for 12ØØ Mhz are rare and VERY expensive. Audio levels and frequencies can be set at the base band radio frequencies (144 Mhz) and the converter oscillator frequency should be set as high up the multiplier chain as possible. If a service monitor cannot be obtained, an oscilloscope can be used to set audio levels and a good quality frequency counter will work for setting the channel frequencies.

Four repeaters were built based on this information and have been in operation with no problems, (one since September 1991). With the addition of a 12 Db preamp for the receiver, the sensitivity was measured at .2 microvolts for 2Ø Db quieting. A filter or cavity will be required between the receiver and antenna or duplexer for the receiver to work in repeater service. Remember, the transverter is a broad band device and there is basically no selectivity tuning so a cavity or filter is also required here.

A good bandpass filter that is fairly easy to build can be found in the RSGB VHF, UHF MANUAL, page 9.2Ø. This simple 3 pole filter has very sharp skirts (5Ø Db down at 8ØØ Mhz) low insertion loss and low SWR.

Acknowledgements

From the beginning, this has been a group project with each member of the group contributing something, anything. In particular are: Robert Boehme, W6RHV, was the first to build one of these repeaters and make it work on the bench. Without his assistance, patience, and test equipment, I would have never made the subsequent units work. Bob also built several 3 pole interdigital bandpass filters. Brian Kantor, WB6CYT, donated his time and skills helping with the audio interfacing and set-up (frequency and deviation setting). Cecil Casillas, WD6FZA, also constructed and donated several bandpass filters.

Construction costs can vary widely, depending on your "junk box", the availability of many items at your local electronics surplus store and other considerations. Probably the single most expensive part will be the duplexer. These can cost upwards from $ 500.00 if purchased new. If this is not in the budget, two antennas with appropriate feedline (1/2 to 7/8"hardline) will be needed. Sometimes two or more persons in our group sponsored one repeater to help keep costs at a reasonable amount.

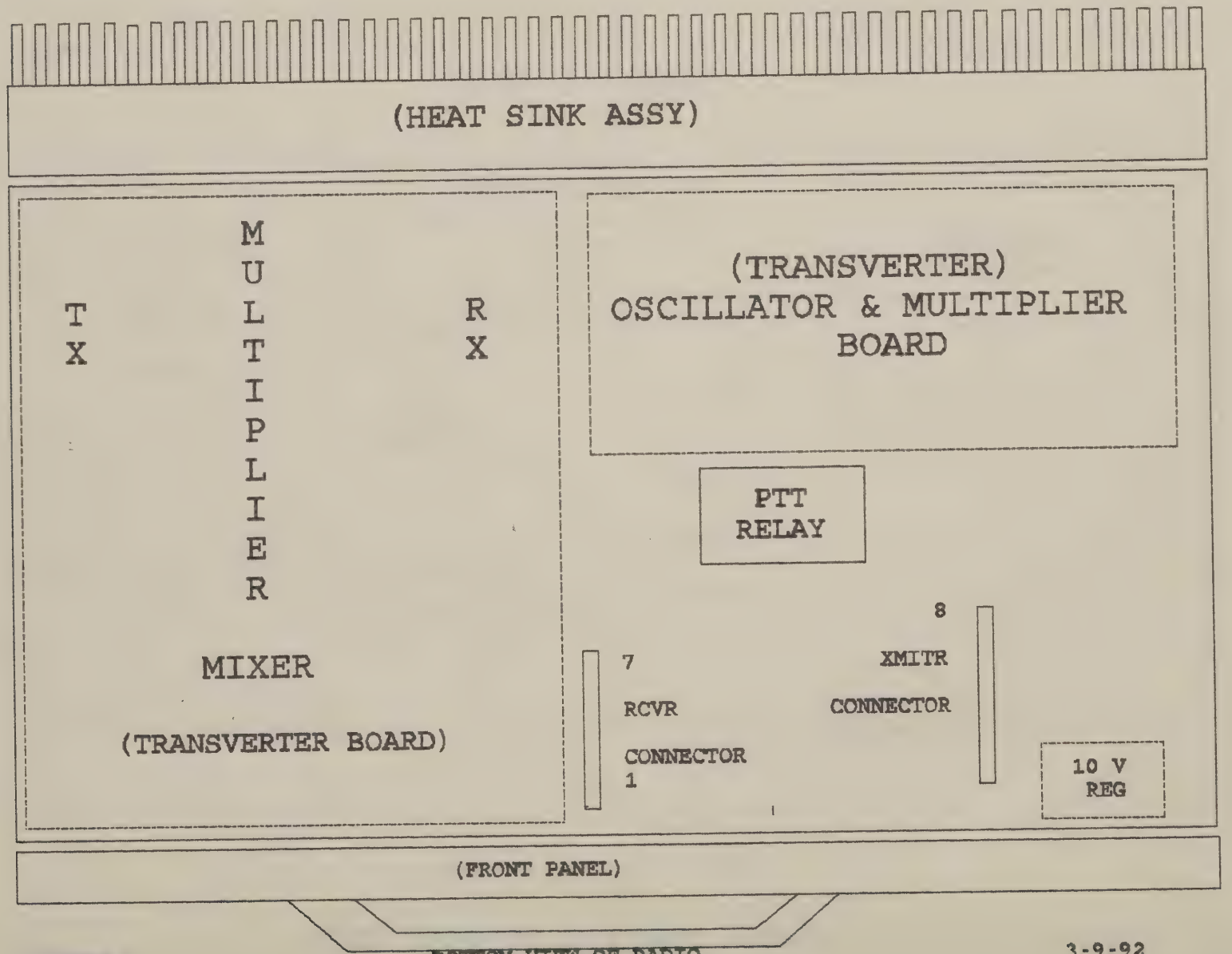
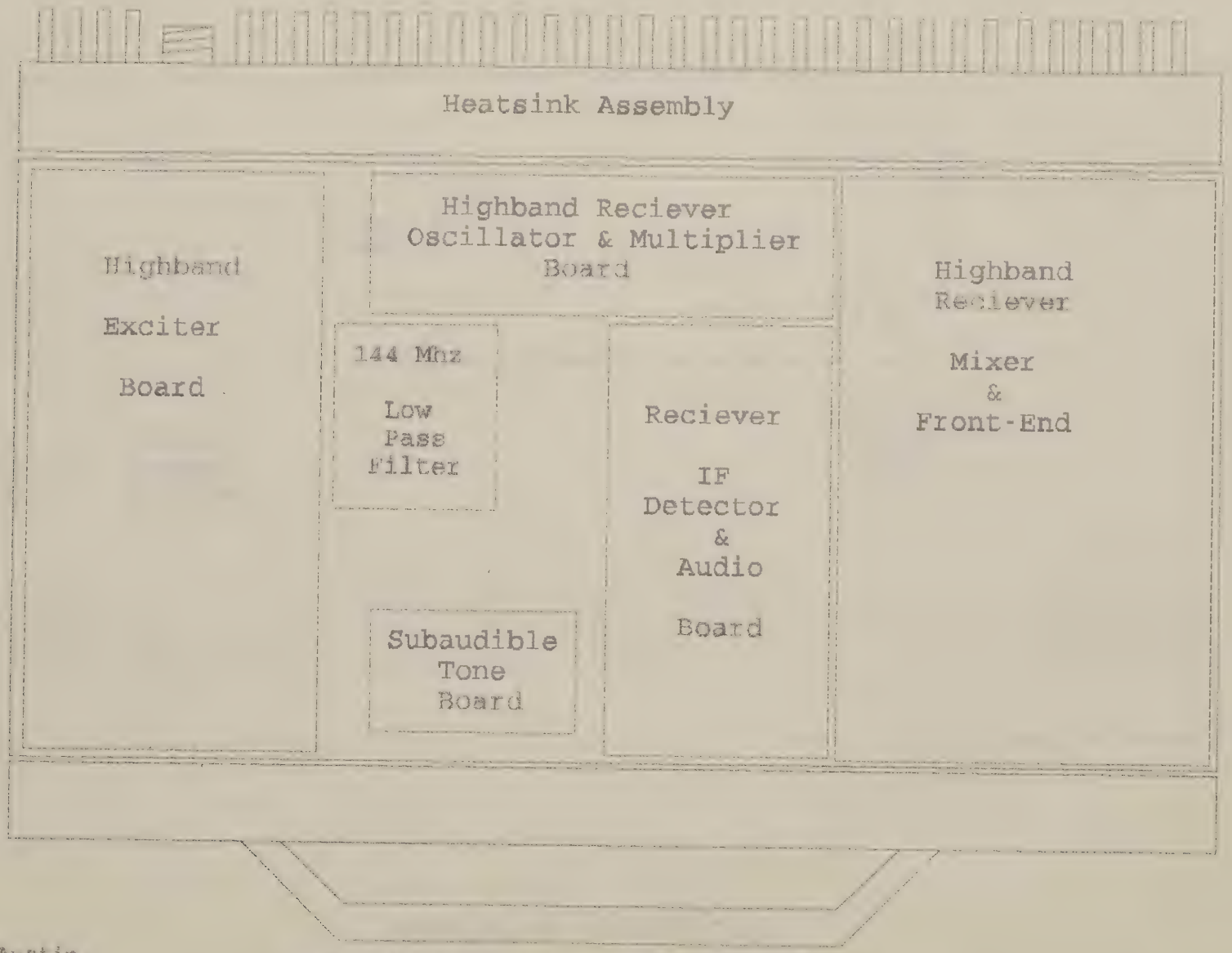


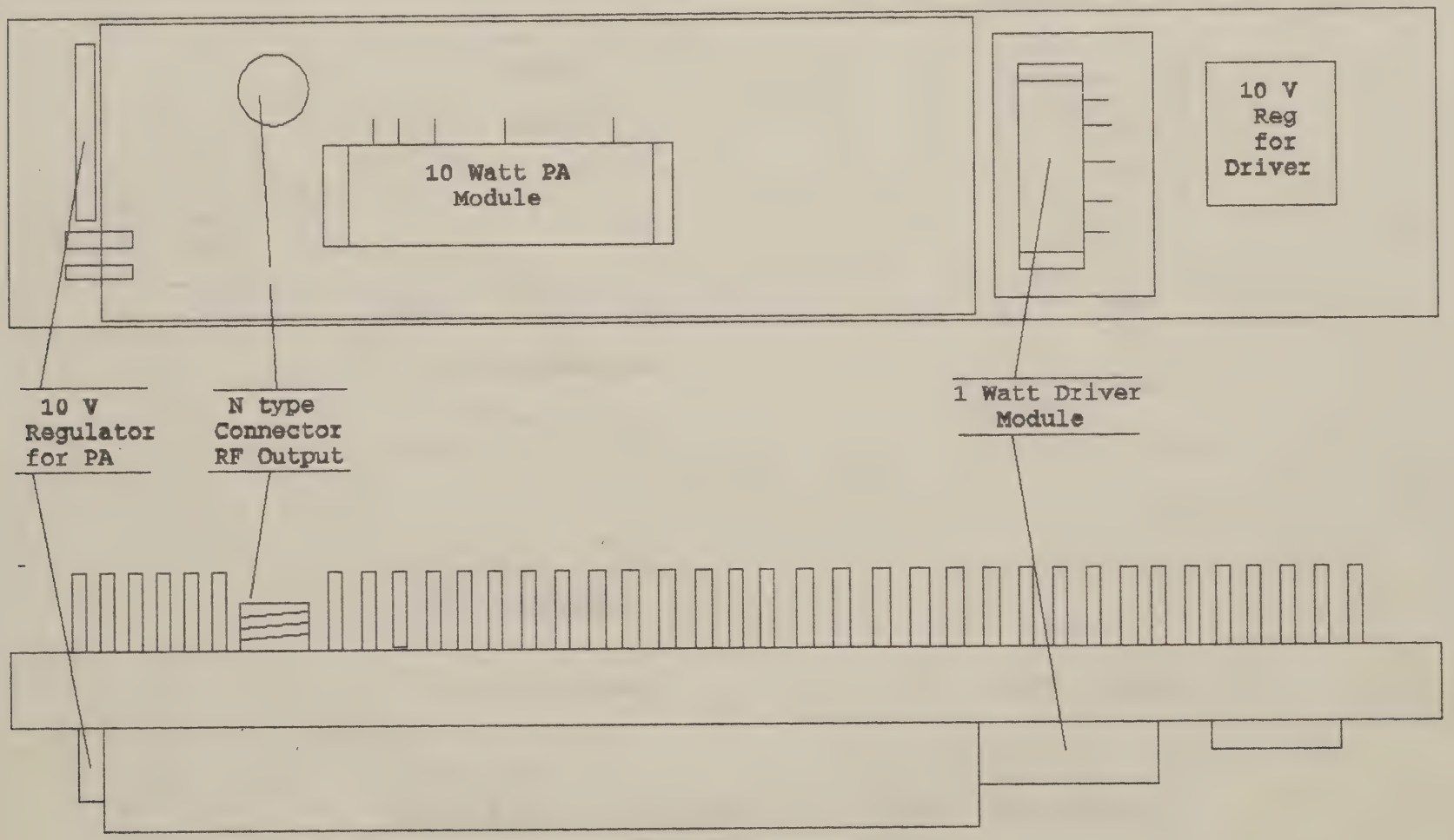
FIGURE 1 BOTTOM VIEW OF RADIO 3-9-92



J. Austin
WA6RLV

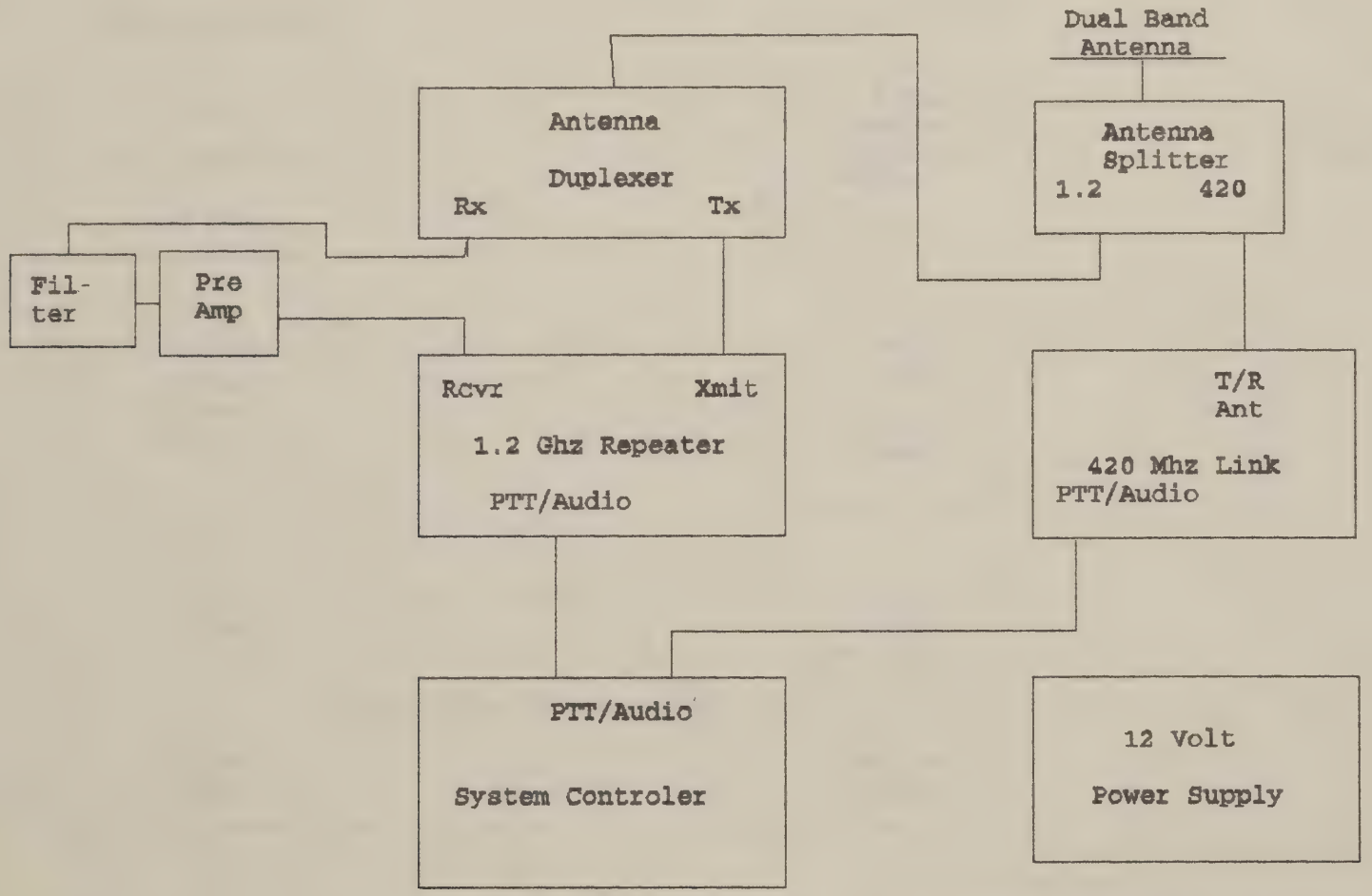
Top View of 1.2 Ghz Repeater

03-19-92

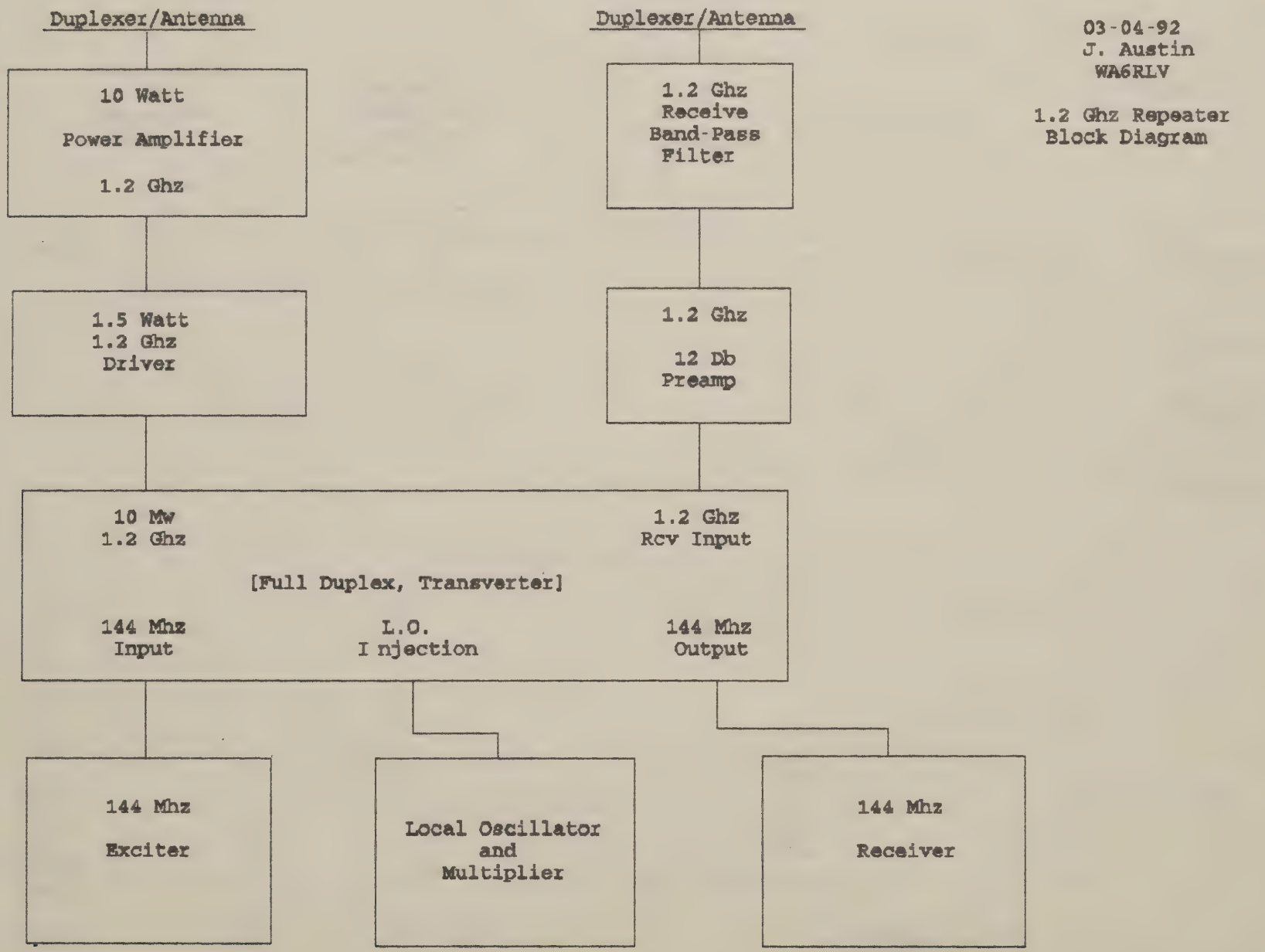


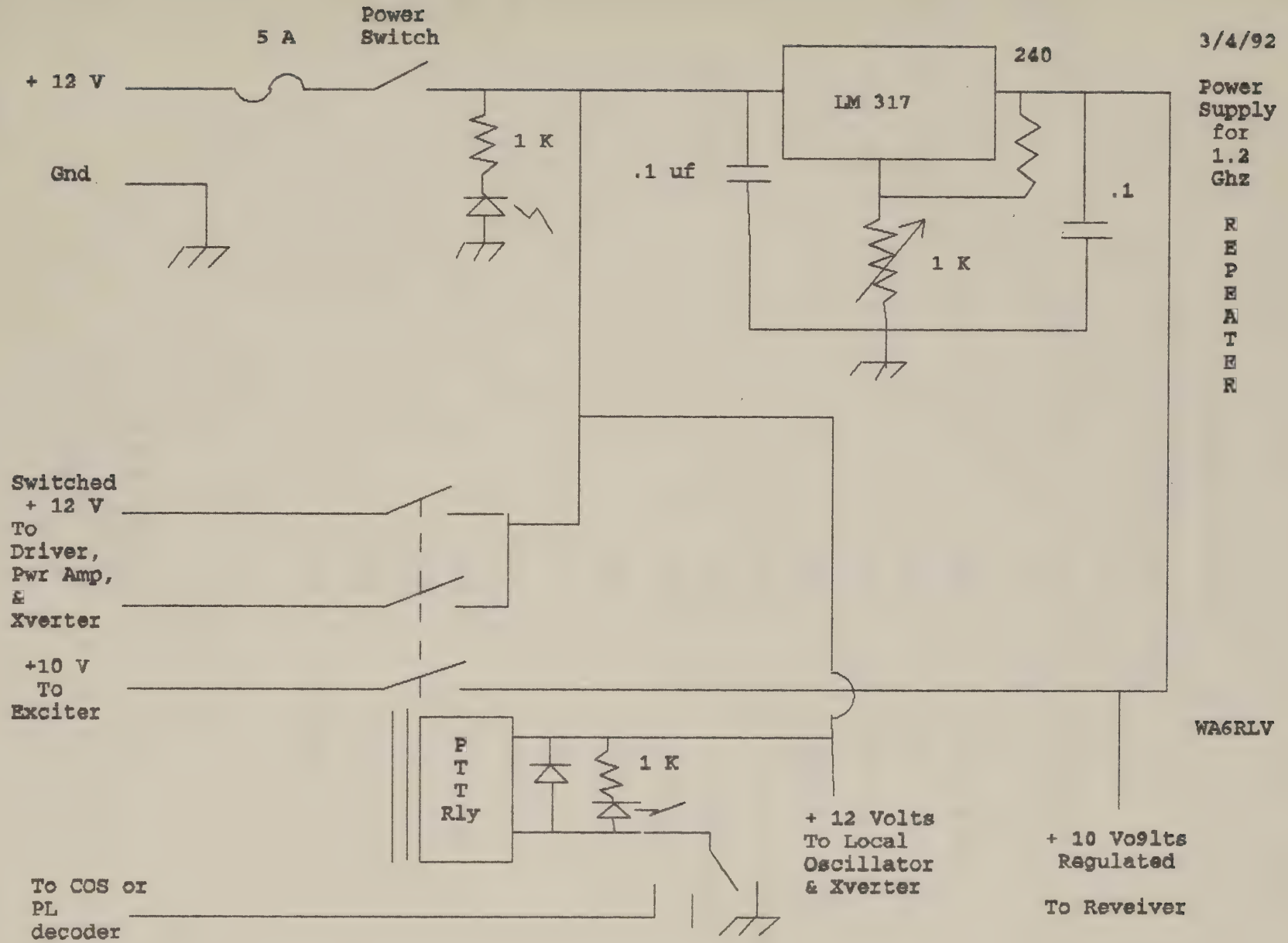
Heatsink Assembly

1.2 Ghz Repeater WA6RLV 03-16-92 J. Austin



C.A.R.E. System 1.2 Ghz Repeater Configuration


Duplexer/Antenna
Duplexer/Antenna
03-04-92
J. Austin
WA6RLV
1.2 Ghz Repeater
Block Diagram
10 Watt
Power Amplifier
1.2 Ghz
1.2 Ghz
Receive
Band-Pass
Filter
1.5 Watt
1.2 Ghz
Driver
1.2 Ghz
12 Db
Preamp
10 Mw
1.2 Ghz
1.2 Ghz
Rcv Input
[Full Duplex, Transverter]
144 Mhz
Input
L.O.
Injection
144 Mhz
Output
144 Mhz
Exciter
Local Oscillator
and
Multiplier
144 Mhz
Receiver


5 A
Power
Switch
+ 12 V
Gnd
1 K
.1 uf
LM 317
240
1 K
.1
3/4/92
Power
Supply
for
1.2
Ghz
R
E
P
E
A
T
E
R
Switched
+ 12 V
To
Driver,
Pwr Amp,
&
Xverter
+10 V
To
Exciter
P
T
T
Rly
1 K
WA6RLV
+ 12 Volts
To Local
Oscillator
& Xverter
+ 10 Vo91ts
Regulated
To Reveiver
To COS or
PL
decoder

1.2 Ghz Repeater

Terminal Strip Connections

Terminal Screw #	Connector Pin #	Color	Purpose
1	7	Red	+12V fused
2 (not used)	-	Red	+12V PA only
3 (not used)	-	Yel	PTT Enable
4	6	Grn	+12V Tx switched
5	-	Red	+12V Fm Sup/Fuse
6 (not used)	-	Red	+12V Fm Fuse/Sw
7	4	Shld	Rx Audio
8	3	Shld	Tx Audio
9	2	Blu	COS
1Ø	1	Org	PTT
11	-	Grn	N.O. Aux Rly
12	-	Grn	N.O. Aux Rly
13	5	Blk	Ground (-)
-	8	Bro	Spare

Ø3-Ø4-92
C.A.R.E. System
1.2 Ghz Repeater
WA6RLV
J. Austin

(rev 6-92)

I.2 Ghz Repeater

Terminal Strip Connections

Terminal Screw #	Connector Pin #	Color	Purpose
1	7	Red	+12V fused
2 (not used)	-	Red	+12V PA only
3 (not used)	-	Yel	PTT Enable
4	6	Grn	+12V Tx switched
5	-	Red	+12V Fm Sup/Fuse
6 (not used)	-	Red	+12V Fm Fuse/Sw
7	4	Shld	Rx Audio
8	3	Shld	Tx Audio
9	2	Blu	COS
10	1	Org	PTT
11	-	Grn	N.O. Aux Rly
12	-	Grn	N.O. Aux Rly
13	5	Blk	Ground (-)
-	8	Brn	Spare

G.E. Master Pin Connections

	Xmitr		Rcvr
1.	+ 1Ø Volts (switched)	1.	Audio Out
2.	Ground	2.	(no connection)
3.	Osc Compensator (rx 5)	3.	+ 1Ø Volts (continuous)
4.	Mic High	4.	Ground
5.	Ground	5.	Osc Compensator (tx 3)
6.	Ground	6.	Ground
7.	Ground	7.	+ 1Ø Volts (continuous)
8.	+ 1Ø Volts (continuous)		
9.	Sub Audible Tone High		
1Ø.	(no connection)		